3.2
Rapid Transuranic Monitoring Laboratory

Figure 3.2

DESCRIPTION

Transuranic (TRU) contaminated rad-wastes have been stored in shallow pits and trenches at many DOE facilities, including the Idaho National Engineering Laboratory (INEL). It is anticipated that waste containers have degraded over the years and, consequently, a significant fraction of the backfill soil in these pits and trenches is now contaminated with TRU elements and long-lived fission and activation products. As an example, INEL has 57,000 m^3 of buried TRU waste material that would account for about 20% of the total volume of contaminated waste that must be removed. The Rapid Transuranic Monitoring Laboratory (RTML) was developed to support TRU waste retrieval efforts by continuously monitoring the air, soil, and deposited dusts for radioactive contaminants.

The RTML is a mobile, field deployable laboratory that can continuously monitor airborne TRU concentration and rapidly analyze soil, smear, and air filter samples for TRU isotopes, and fission products. The RTML consists of a collection of monitoring devices that are capable of measuring low-level concentrations of alpha- and photon-emitting contaminants. The laboratory is housed in two separate trailers that provide sample storage and preparation areas and counting laboratory space. The power can be supplied by portable 30 and 50 kW diesel generators in remote applications. One trailer (2.4 m × 7.3 m) houses the sample preparation laboratory that is equipped with a Class-A fume hood, having high efficiency particulate air (HEPA) filters, a gravity-flow drying oven, sieving equipment, two analytical balances, compressed air cylinders, hot plates, and a supply of sample planchets and containers. Samples are received and prepared for analysis in this trailer following specific procedures developed for the RTML.

The second trailer (2.4 m × 14.6 m) is equipped with: (1) a germanium photon spectrometer installed in an automatic sample changer, (2) two large-area ionization chamber alpha spectrometers, (3) a VAX 4000 model 100 computer, (4) four computer terminals with monitors, and (5) a laser printer. All three measurement systems are controlled from the VAX 4000-series computer that controls operation, analyzes spectral data acquired by the spectrometers, and displays and generates the analysis results reports. The RTML is also equipped with four alpha continuous air monitors (CAMs). The alpha CAMs can be operated up to 200 m from the trailer. See Figure 3.2.

TECHNICAL PERFORMANCE

Photon Analysis Spectrometer. The spectrometer consists of a 60 mm diameter, n-type, extended-range germanium detector capable of efficiently measuring both x-rays and gamma-rays. The gain is chosen to cover photon energies from about 10 to 1,380 keV with an 8,192 channel analyzer. The photon analysis spectrometer determines the presence of plutonium radioisotopes by counting the L-shell x-rays emitted by the uranium daughters. It also determines the presence of radionuclides such as ^{60}Co, ^{137}Cs, and ^{241}Am that emit gamma rays having energies below 1,380 keV. The gamma-ray and X-ray data are obtained in one spectrum, and two spectral analytical methods are applied simultaneously to the different regions of the spectrum.

Large Area Ionization Chamber Alpha Spectrometers. Two gridded ionization chambers constructed of nickel-plated milled steel are used. The chambers are rated to 100 kPa above atmospheric pressure. The sample holders are held in a reproducible geometric arrangement by fixed guides. The fixed guides have milled cutouts to hold both 254 mm circular pans, and 200 × 250 mm filters.

Alpha Continuous Air Monitors. The alpha CAMs are equipped with two-stage virtual impact detectors to remove the background radon progeny--improving the sensitivity. The impactor also concentrates the airborne TRU-bearing particulates. Each CAM has two air sampling pumps, two mass flow sensors, a 900 mm^2 detector with 4 mm thick collimator, a detector bias supply, a preamplifier, a linear amplifier, a

Sample Preparation. Each soil sample is baked 30 to 60 min at 175°C until the sample is dry, then sieved in a 50-mesh sieve. At this stage, 11 g of the sieved soil is weighed into a circular plastic container (3 mm × 64 mm diameter) for analysis using the photon spectrometer. Preparation for the ionization chamber alpha spectrometer is similar but also requires grinding of a 100 mg sieved soil sample in a diamonite mortar in an aqueous solution of 30% ethanol. The resulting suspension is transferred to an air operated sprayer and subsequently sprayed onto a preheated 254 mm diameter stainless steel pan.

Field Test Results. Field trials were conducted in the summer of 1993 as part of a remote retrieval demonstration involving a weather shield, remote retrieval equipment, and dust control equipment. The demonstration showed the capability of processing 100 samples per day of soil, filter, and smear samples at the stated lower levels of detection (LLD). During the field trial, hundreds of soil samples plus 20 specially prepared standards were analyzed by the RTML. The sensitivity and reliability to which alpha and gamma emitting radionuclides could be detected under field conditions were demonstrated by analyzing 20 soil standards containing known activities of ^{239}Pu, ^{241}Am, ^{60}Co, and ^{137}Cs. These standards were also randomly distributed among the cold test pit (CTP) soil samples for the blind test before delivery to the RTML preparation trailer.

Under field conditions, the lower detection limit (LLD) concentrations for ^{239}Pu, ^{241}Am, ^{60}Co, and ^{137}Cs by x-ray/gamma-ray spectrometry were confirmed to be 40, 1, 5, and 5 pCi/g, respectively, for 10 minute counts. The RTML unit can measure isotopic plutonium at 20 pCi/g using 15 minute counts. LLD concentrations for ^{239}Pu and ^{241}Am by large area ionization chamber alpha spectrometry were both 40 pCi/g. The LLD concentrations for the four RTML alpha CAMs were shown to be less than 1 derived air concentration (DAC) in 1-hr when airborne dust concentrations were below 0.01 mg/L.

None of the analyses in either the 143 CTP samples analyzed by photon spectrometry or the 96 CTP samples analyzed by ionization chamber alpha spectrometry showed manmade radiation. That is, there were no false positives for any of the 239 blank soil samples analyzed. The maximum number of samples analyzed in a 24-hour period with the photon spectrometer was 79; with the two ionization chambers, it was 33. Therefore, the total sample throughput rate was demonstrated to be 112 samples in 1 day, working one 8 hour shift. For an environmental restoration project such as a pit retrieval, 100 samples per day should be adequate to track contamination levels; therefore on-line tracking is essentially available. A true "on-line" tracking of ^{239}Pu content is presently not possible.

Cost. RTMLs can be procured for $500K. Operations and maintenance costs include four technicians and 10% time assistance from scientists. Life-cycle costs have not been estimated. Thermo Terratech estimated that using the RTML at DOE Formerly Utilized Sites Remedial Action Program (FUSRAP) sites will save the DOE $250K and 6 months in schedule.

PROJECTED PERFORMANCE

To provide the RTML the capability to directly measure ^{90}Sr in soil during FY 1994, two different large area beta detectors were developed and experimentally evaluated; a triple proportional counter beta detector operated in the coincidence mode, and a large-area scintillation beta detector. A third large-area beta detector (the real-time ^{90}Sr analyzer developed at Pacific Northwest Laboratories) was also experimentally evaluated. Of the three beta detectors tested, the triple proportional counter beta detector had the best sensitivity for ^{90}Sr in soil. Its LLD for a 10 minute count time was 1 pCi/g ^{90}Sr for a 150 g soil sample.

Alpha continuous air monitors equipped with a single fixed sample collection filter are not very reliable when the concentrations of airborne contaminants remain elevated over time. To provide a means of measuring at regular intervals (the total activity of each TRU isotope accumulated on the sample collection fiber) an alpha CAM was built that is equipped with two solid-state silicon detectors and three 47 mm diameter sample collection filters mounted at 120° intervals on a rotatable disk. The second detector intermittently measures the total activity of each TRU isotope accumulated on each of the three sample collection filters. A two-stage inertial impactor that samples at 283 L/minute removes most of the alpha-emitting radon and thoron daughters from the sample airstream before the airstream traverses the sample collection filter.

APPLICABILITY

The RTML monitors low-level concentrations of actinides and fission products in soils, fallout coupons, filters, air, and liquids.

STATUS

The RTML was field tested in FY 1993. The RTML unit was field deployable in 1994. It was transferred in March 1995 to Thermo Terratech of Albuquerque, NM, for use in monitoring radioactive contaminants at different DOE sites throughout the country that are being remediated under FUSRAP. The RTML was recently moved to the Oak Ridge National Laboratory for installation of additional analytical instrumentation; it will then be put into service at Savannah River Site.

REGULATORY CONSIDERATIONS

Ecological impacts are not anticipated from use of the RTM unit. Samples for the RTM unit will be standard health-physics wrapped and will be prepared under a Class A hood.

POTENTIAL COMMERCIAL APPLICATIONS

Potential commercial applications include monitoring of radioactive contaminated retrieval areas and separation, processing, and storage systems. The RTML could also be applied in accident mitigation and cleanup.

BASELINE TECHNOLOGY

The baseline for rapid monitoring during retrieval is "in laboratory" analysis and health-physics handheld instruments. Handheld instruments can provide gross alpha measurements on surface soils at the 5,000 to 10,000 pCi/g levels in minutes. Laboratory measurements can provide 4 samples per radiochemist per day at the 0.2 pCi/g level. Alpha CAMs "off the shelf" currently provide about 80 DAC-h sensitivities.

INTELLECTUAL PROPERTY

The following patents were issued or are pending:

- Photon spectrometer analysis system, U.S. Patent 5,206,174 issued April 27, 1993.
- Pulser for gamma-ray spectrometry, U.S. Patent 4,968,889 issued November 6, 1990.
- Alpha CAM, U.S. Patent Application S-81, 110.

The RTML technology was transferred to Thermo Terratech in 1995. An equipment loan agreement and a license agreement between Lockheed Idaho Technologies Company (which manages and operates INEL for the DOE) and Thermo Terratech was signed in March to set the terms and conditions for loaning the RTML to Thermo Terratech for one to five years.

For more information, please contact:

Center for Environmental Management Information
1-800-736-3282

Principal Investigators
Charles V. McIsaac, Claude W. Sill, and
Robert J. Gehrke
Lockheed Idaho Technologies Company
P.O. Box 1625
Idaho Falls, ID 83415
(208) 533-4020, (208) 533-4024, and
(208) 526-4155

DOE Program Manager
Jaffer Mohiuddin
U.S. Department of Energy
Cloverleaf Building
19901 Germantown Road
Germantown, MD 20874-1290
(301) 903-7965

Industrial Partners

Ordella
Oak Ridge, TN

Thermo Terratech
Albuquerque, NM

REFERENCES

1. McIsaac, C.V., C.W. Sill, R.J. Gehrke, and L.O. Johnson, Rapid Transuranic Monitoring Laboratory Final Report, INEL/94-0246, April 1995.

2. Sill, C.W., "Rapid Monitoring of Soil, Water, and Air Dusts by Direct Large-Area Alpha Spectrometry," submitted to Health Physics, October 1994.

3. McIsaac, C.V., C.W. Sill, and R.J. Gehrke, Test Plan for Preparing the Rapid Transuranic Monitoring Laboratory for Field Deployment, EGG-WTD-11208, April 1994.

4. McIsaac, C.V., C. W. Sill, R.J. Gehrke, E.W. Killian, K.D. Watts, and C.R. Amaro, Field Test of Rapid Transuranic Monitoring Laboratory, EGG-WTD-10935, December 1993.

5. McIsaac, C.V., C.W. Sill and R.J. Gehrke, Operating Procedures for Rapid Transuranic Monitoring Laboratory, EGG-WTD-10898, October 1993.

6. DOE-ID, "Technology Information Profile (rev. 2), Technology Name: Rapid Transuranic Monitoring Unit," TTP Reference No. ID-121210, March 25, 1993.

7. McIsaac, C.V. and C.R. Amaro, Sensitivities of Five Alpha Continuous Air Monitors for Detection of Airborne ^{239}Pu, EGG-WTD-10314, July 1992.

8. Gehrke, R.J., et al., "Rapid Assay of Plutonium in Soils by Passive L X-ray Counting," Transcript of the American Nuclear Society, Vo.l 64, No. 94, 1991.

9. Sill, C.W., Rapid Monitoring for Transuranic Contaminants during Buried Waste Retrieval, EGG-WTD-9412, March 1991.

10. Loomis, G.G., and C.V. McIsaac, "Rapid Monitoring of Transuranic Contaminants during Buried TRU Waste Retrieval," Proceedings of Waste Management '91, Tucson, AZ, February 24-28, 1991.

11. McIsaac, C.V., et al., "Sensitivities of Alpha Continuous Air Monitors for Detection of Airborne ^{239}Pu," Proceedings of Waste Management '91, Tucson, AZ, February 24-28, 1991.

Back to Table of Contents

Characterization, Monitoring and Sensor Technology Catalogue, September 1995
